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Notes on the life cycle of *Scaeurgus unicirrhus* (Cephalopoda: Octopodidae)

Notas sobre el ciclo vital de *Scaeurgus unicirrhus* (Cephalopoda: Octopodidae)

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Recibido el 2-IX-2006. Aceptado el 8-I-2007

ABSTRACT

The examination of 34 specimens of *Scaeurgus unicirrhus* (Cephalopoda: Octopodidae), collected in spring (1986 - 1987) in the southern Tyrrhenian Sea, contributed to the previously scant knowledge of its life cycle. No significant differences were found between mean sizes and mantle length (*ML*)-weight (*W*) regressions of the two sexes; the regression line equation for all specimens pooled is $\ln W = -8.257 + 2.938 \ln ML$. The sample was composed of two cohorts; the first one contained only juveniles (*ML* range: 20-42 mm, $\overline{ML}_1 = 30.89$ mm), the second one subadults and adults (*ML* range: 49-82 mm, $\overline{ML}_2 = 66.52$ mm). This fact suggests a two-year life cycle: spawning in spring and early summer, egg development for 2.5 months, paralarvae living comparatively long in the plankton, settlement of juveniles in autumn-winter, and growth for one year or more to reach sexual maturity and reproduce. The count of gill lamellae (range of outer demibranch lamellae: 11-14) suggests that their number (7 lamellae at hatching), after gradually increasing during the planktonic phase, most probably becomes fixed by the time the paralarvae settle to the bottom.

RESUMEN

El estudio de 34 ejemplares de *Scaeurgus unicirrhus* (Cephalopoda: Octopodidae), colectados en la primavera (1986 - 1987) en el Mar Tirreno meridional, ha permitido mejorar el conocimiento, hasta la fecha escaso, de su ciclo vital. No se encontraron diferencias significativas entre tamaños medios y entre regresiones longitud del manto (*ML*)-peso (*W*) de ambos sexos; la ecuación de regresión para el conjunto de los ejemplares es $\ln W = -8{,}257 + 2{,}938 \ln ML$. La muestra aparece formada por dos cohortes, la primera con solamente juveniles (valores de *ML*: 20-42 mm, $\overline{ML}_1 = 30{,}89$ mm), la secunda con subadultos y adultos (valores de *ML*: 49-82 mm, $\overline{ML}_2 = 66{,}52$ mm). Este hecho sugiere que el ciclo vital es de dos años: puesta en primavera y al principio del verano, desarrollo de los huevos en 2,5 meses, paralarvas con una vida planctónica relativamente larga, asentamiento de los juveniles en otoño-invierno y crecimiento durante un año o más hasta alcanzar la madurez sexual y reproducirse. El recuento de las lamelas branquiales (número de lamelas en la demibranquia externa: 11-14) indica que el número de estas (7 lamelas en la eclosión), después de aumentar gradualmente durante la fase planctónica, se estabiliza muy probablemente en el momento en que las paralarvas se asientan en el fondo.

KEY WORDS: Cephalopoda, *Scaeurgus*, life cycle, Tyrrhenian Sea, Mediterranean.
PALABRAS CLAVE: Cephalopoda, *Scaeurgus*, ciclo vital, mar Tirreno, Mediterráneo.

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INTRODUCTION

Scaeurgus unicirrhus (Delle Chiaje, 1841) is one of the ten octopodids living in the Mediterranean Sea (BELLO, 2003). Despite the fact that it is not a rare species in certain parts of its range, little is known about its biology and ecology. Most extant information on its life cycle comes from MANGOLD-WIRZ (1963). BOLETZKY (1977, 1984) reported on its embryonic development and showed that the so called *Macrotritopus* is not a paralarval stage of *S. unicirrhus*, as proposed by REES (1954), but rather of *Octopus defilippi* Verany, 1851. BELLO (2004) gave the first description of an advanced stage of wild-collected *S. unicirrhus* paralarvae, which seemingly undergo a long planktonic phase. As for its distribution in the Mediterranean and especially in Italian waters, BELCARI (1999) summarized that it is quite a rare or seldom found species that is more frequently caught in the Sicilian Channel. BELCARI (1999) also reported that it lives in depths of 50 to 800 m, but most commonly in depths of 100 to 350 m on sandy, muddy, or coralline ("white coral") substrates. The actual geographical range of *S. unicirrhus* is unknown. Until a few years ago it was considered to be cosmopolitan in tropical and temperate waters (e.g. GUERRA, 1992), however, its range has since been shown to be limited to the Atlanto-Mediterranean region (MANGOLD, 1998), and it is not clear whether the *Scaeurgus* populations living in the western and eastern Atlantic Ocean respectively belong to the same or two sibling species (NORMAN, 2000).

Knowledge of the life cycle of this left-hectocotylized octopus is still poor, and the purpose of this note is to improve it through the examination of a sample of *S. unicirrhus* collected in the southern Tyrrhenian Sea (western Mediterranean). Moreover, additional data on the number of gill lamellae, a diagnostic character, are reported.

MATERIAL AND METHODS

Thirty-four *Scaeurgus unicirrhus* individuals were collected by trawling in the Gulf of Castellammare, northern coast of Sicily, southern Tyrrhenian Sea, with eight individuals captured in spring 1986 (1 April to 8 May) and 26 in spring 1987 (26 March to 17 May) respectively. The depth of capture ranged from 70 to 580 m. For further details on collection see BELLO, PIPITONE AND ARCULEO (1994).

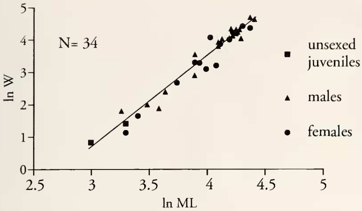
Soon after capture, the octopus were placed in plastic bags and frozen. After thawing, the following measurements were taken on each specimen: mantle length, *ML*, to the nearest mm and body weight, *W*, to the nearest 0.1 g. The mantle cavity was then cut open to determine sex and maturity stage. In addition the lamellae of both outer demibranches were counted.

Regression analysis (SOKAL AND ROHLF, 1981) of the *ML*–*W* relationship was conducted following natural log-transformation of the data. Regression lines for males and females were compared using a Student's *t*-test (MAYRAT, 1959). *ML* frequency distributions were analyzed to define size cohorts (BHATTACHARYA, 1964). Mean gill lamellae counts for males and females were compared using a Student's *t*-test.

RESULTS

Comparison of the ln *ML*–ln *W* regression lines for male and female *Scaeurgus unicirrhus* did not show any significant difference (t_{slope}= 0.906, df= 28, P_t= 0.372; $t_{position}$= 1.142, df= 29, P_t= 0.263). Hence the data from all specimens (19 males, 13 females, and 2 unsexed juveniles) were pooled and the overall functional regression line derived, $\ln W = -8.257 + 2.938 \ln ML$, r= 0.978, df= 32, $P_r << 0.0001$ (Fig. 1). In addition, no significant difference was found between both the mean and the variance of *ML* values of the two sexes ($t_{\bar{x}}$= 0.454, df= 30, P_t= 0.653; F= 1.144, P_F= 0.410), which indicates that males and females have similar growth rates.

The size (*ML*) frequency distributions (males and females pooled) of both years were bimodal. Despite the mean size of both cohorts being smaller in spring 1986



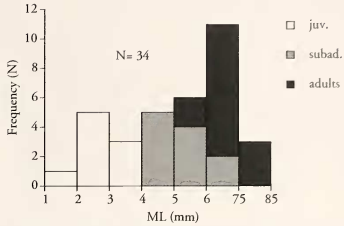


Figure 1. Functional regression line 'mantle length – body weight' of *Scaeurgus unicirrhus* (data log-transformed). All specimens pooled. *ML*= mantle length, *W*= body weight. Figure 2. Mantle length frequency distribution of *Scaeurgus unicirrhus*. All specimens pooled.
Figura 1. Línea de regresión funcional 'longitud del manto – peso corporal' de Scaeurgus unicirrhus *(datos con transformación logarítmica). Todos los ejemplares reunidos. ML= longitud del manto, W= peso corporal. Figura 2. Distribución de frecuencias para la longitud del manto en* Scaeurgus unicirrhus. *Todos los ejemplares reunidos.*

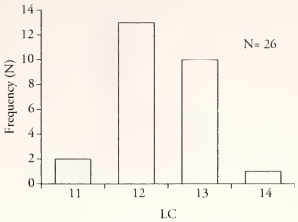
than in spring 1987, comparison did not show any significant difference ($t_{\bar{x}}$= 0.551, *df*= 32, P_t= 0.586; *F*= 1.185, P_F= 0.427); hence the data from both years were pooled. Figure 2 shows the overall size frequency distribution and individual maturity stages. In particular the first cohort (n_1= 9, $\overline{ML}_1$= 30.89 mm) was composed of juveniles. The second cohort (n_2= 25, $\overline{ML}_2$= 66.52 mm) contained subadults, some of them very close to maturity, and several mature specimens, that is males with spermatophores in the Needham sac and females with smooth eggs. The *ML* of mature specimens ranged from 60 to 82 mm in males (n= 10) and from 66 to 79 mm in females (n= 4), three of which were mated, and one spent.

Gill lamellae counts (*LC*) ranged from 11 to 13 in males and from 12 to 14 in females; one unsexed juvenile had 13 lamellae. The outer demibranches of the gills of all specimens were symmetrical as far as the number of lamellae is concerned. The comparison of mean lamellae counts for males ($\bar{x}$= 12.19) and females ($\bar{x}$= 12.67) did not show any significant difference ($t_{\bar{x}}$= 0.101; *df*= 23; P_t= 0.920), hence the counts for both sexes were pooled. The overall frequency distribution is graphed in Figure 3; its parameters are: mode= 12 lamellae; mean *LC*= 12.38 lamellae, standard deviation σ= 0.70. Most specimens (88.5%) had either 12 or 13 lamellae. The slope of the predictive regression line *LC-ML* (all specimens pooled) (Fig. 4) was not significantly different to 0 (*b*= –0.012; s_b= 0.008; t_s= –1.492; *df*= 24; P_t= 0.149), that is to say that the number of lamellae does not increase with age in benthic individuals. Indeed the smallest examined specimen (juv., *ML*= 20 mm) had 13 lamellae per outer demibranch, whereas the largest ones (one male and one female, both 79 mm *ML*) bore 12 lamellae.

DISCUSSION

The occurrence of two cohorts in the sample strongly suggests a two-year life cycle for *Scaeurgus unicirrhus*. According to the available data in the literature and present results the following life cycle may be proposed for the southern Tyrrhenian (sub) population (Fig. 5):

- Spawning goes on for at least three months in spring and early-middle summer. This hypothesis is based on the presence in the sample of fully mature and mated females, one of which was spent (male condition is not indicative of the timing of the spawning period, since in most octopodids males mature much earlier than females [MANGOLD-WIRZ, 1963]). The hypothesis is also supported by BOLETZKY's (1984) report of



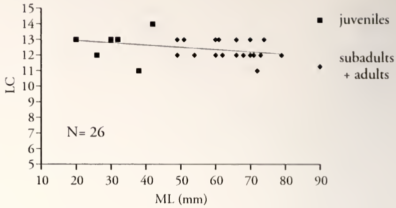


Figure 3. Gill lamellae frequency distribution of *Scaeurgus unicirrhus*. All specimens pooled. *LC*= lamellae count. Figure 4. Predictive regression line 'number of outer demibranch lamellae – mantle length' of *Scaeurgus unicirrhus*. All specimens pooled. *LC*= lamellae count, *ML*= mantle length.
Figura 3. Distribución de frecuencias para el número de lamelas branquiales en Scaeurgus unicirrhus. *Todos los ejemplares reunidos. LC= recuento de lamelas. Figura 4. Línea de regresión predictiva 'número de lamelas de la demibranquia externa – longitud del manto' en* Scaeurgus unicirrhus. *Todos los ejemplares reunidos. LC= recuento de lamelas, ML= longitud del manto.*

two spawning events in an aquarium on the 10th of May and towards the end of June respectively, and by MANGOLD's (1998) statement that the spawning period is from May to August.

- The egg brooding period, according to BOLETZKY's (1984) data, may be inferred to last at least 2.5 months at 13-14°C in the Mediterranean. Moreover such a time span is consistent with the incubation time in degree-days for *Octopus vulgaris* Cuvier, 1797 (MANGOLD-WIRZ, 1963), an octopodid with eggs of comparable size. The occurrence of paralarvae on the 8th of August in the Adriatic Sea (BELLO, 2004) is consistent with both the hypothesized spawning season and length of the brooding period.

- A comparatively long planktonic phase during which the paralarva grows in size from 2.0 mm *ML* at hatching (BOLETZKY, 1977) to at least 10 mm *ML* (size of the largest observed paralarva [BELLO, 2004]).

- Paralarvae settle to the bottom in autumn-winter. At settlement *S. unicirrhus* juveniles look like miniature adults with the 'arm length/mantle length' ratio much higher than in paralarvae. The smallest benthic juvenile in the Castellammare sample was 20 mm *ML*; the smallest trawl-collected benthic juveniles were 16 and 18 mm *ML* (preserved specimens from the Sicily Channel) (pers. observ.).

- In spring juveniles range in size from 20 to 42 mm *ML*. Hence they need to live for one more year to reach sexual maturity and reproduce in the following spring.

If the above hypothesis holds true, it follows that *S. unicirrhus* is a comparatively slow growing octopod, which is consistent with the temperature range for the waters in which it is found (13-14°C). This species is of Mauretanic affinity (NESIS, 1987), hence the life cycle of the Mediterranean population probably lengthened to adjust to Mediterranean temperatures, which are somewhat colder than the tropical Atlantic ones. Unfortunately no data are available about the biological cycle of the eastern Atlantic populations of this species to verify such a supposition. However in this regard see LAPTIKHOVSKY, PEREIRA, SALMAN, ARKHIPOV AND COSTA (in press) for the effects of different environmental conditions on maturation of eastern and western Mediterranean cephalopod populations.

MANGOLD-WIRZ (1963) described two females close to maturity from the Catalan Sea sized 116 and 118 mm *ML*, which is much larger than mature females from Castellammare. Those females had been collected in early August, with MANGOLD-WIRZ (1963) hypothesizing that *S. unicirrhus* spawns in late August – early Sep-

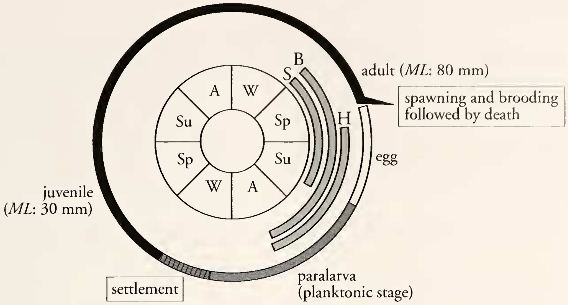


Fig. 5. Life cycle of *Scaeurgus unicirrhus* in the southern Tyrrhenian Sea. Innermost circle, biennial wheel of time (W: winter; Sp: spring; Su: summer; A: autumn). Intermediate incomplete circles, from inside to outside, S: spawning period; B: brooding period; H: hatching period. Outermost circle, an average female life cycle.
Fig. 5. Ciclo vital de Scaeurgus unicirrhus *en el Mar Tirreno meridional. Círculo interno, ciclo temporal de dos años (W: invierno; Sp: primavera; Su: verano; A: otoño). Círculos incompletos intermedios, desde dentro hacia fuera, S: periodo de puesta; B: periodo de incubación; H: periodo de eclosión. Círculo externo, ciclo vital promedio de una hembra.*

tember. Her discussion based on the occurrence of "larvae" is obviously incorrect since at that time *Macrotritopus* was wrongly supposed to represent the *S. unicirrhus* early juvenile stage (cf. BOLETZKY, 1977, 1984). The differences in the timing of the life cycle phases and in size between southern Tyrrhenian (present results) and Catalan females (MANGOLD-WIRZ, 1963) might be due to environmental differences along the north-south Mediterranean gradient. In this respect geographical differences in biological parameters of this species deserve to be investigated. Also the very different densities of this cephalopod in different Mediterranean areas (BELCARI, 1999) are probably linked to the different environmental conditions.

In addition to what was reported in BELLO (2004) about branchial lamellae, i.e. that their number increases from 7 lamellae in the outer demibranch at hatching [BOLETZKY, 1984]) to some 11 lamellae in half grown paralarvae, it is now clear that their number is likely to be fixed by the time the paralarvae settle, since no positive correlation was found between gill lamellae count and body size in settled individuals (Fig. 4). Incidentally, the *LC* of southern Tyrrhenian *S. unicirrhus* corresponds to those reported in the literature, viz. ROPER, SWEENEY AND NAUEN (1984): (11) 12-13 (14); MANGOLD AND BOLETZKY (1987): 11-14; NESIS (1987) and MANGOLD (1998): 12-14.

There are some important missing pieces of the puzzle still needed to fully understand the life cycle of *S. unicirrhus*, which include the location of its spawning and brooding grounds (all octopodids known to date brood their eggs [BOLETZKY, 1994]) and mechanisms developed to counteract the dispersal of its long-lived paralarvae to grounds unsuitable for settlement.

ACKNOWLEDGEMENTS

I wish to thank Marco Arculeo for allowing me the use of the cephalopod sample, Carlo Pipitone for helping in taking measurements, Angel Guerra for critically reading the MS, and Jayson Semmens for critically reading the MS and polishing the English text.

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